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ABSTRACT

This paper outlines hurdles to using the World Wide Web for learning, specifically in a collaborative knowledge-construction environment. Theoretical solutions based directly on existing Web environments, as well as on research and system prototypes in the areas of Intelligent Tutoring Systems (ITS) and ITS authoring systems, are suggested. Topics discussed include: (1) education for the 21st century--global issues grounded in the local community; (2) the complexity of our understanding of the world in some areas of science, resulting in increasing difficulty in relating the interrelations and subtleties to a classroom of passive learners; (3) hurdles toward reaching a learning Web, including relevant Web and hypertext background, problems with implementing workgroup annotations, and media-based authoring; (4) MeTaL (meta-tool for active learning), a knowledge-based tool for collaborative knowledge construction; (5) project-based learning in the global village; (6) the form versus content issue, moderators, voting, verbal skills, and democracy; (7) MeTaL hurdles, including computer science issues, databases, and machine learning; and (8) MeTaL design contributions. Contains 17 system references and 16 references. (DLS)

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# Collaborative Learning and Knowledge-Construction Through a Knowledge-Based WWW Authoring Tool

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**Abstract:** The World Wide Web has huge potential as a medium for learning, both in and out of classrooms. As more and more schools obtain access to the internet, learners (including parents, teachers, and students) are realizing that the web is not particularly useful for substantial educational use in it's raw form. This is primarily due to the lack of collaborative knowledge-construction facilities integrated into the web framework as well as the lack of guiding structure and dynamic management of link and nodes. This paper outlines the hurdles one faces in using the web for learning, specifically in a collaborative knowledge-construction environment. It then suggests some theoretical solutions based directly on existing web environments, as well as on research and system prototypes in the areas of Intelligent Tutoring Systems (ITS) and ITS authoring systems.

## Introduction

### Education for the 21st century -- Global issues grounded in the local community

"The more things change, the more things stay the same." In a February 1996 interview with Wired magazine, Steve Jobs commented that when one looks at the big picture, computers haven't changed the fundamentals of what life is about, "We're born, we live for a brief instant die. It's been happening for a long time. Technology is not changing it much, if at all." [Wolf 1996] This is a powerful statement coming from Jobs, who, in a previous incarnation as the co-founder of Apple computer, made it his mission to revolutionize education by bringing Apple computers to classrooms around the United States. Regardless of Jobs' credentials, the comment does ring true, and we see it in our school systems as we struggle to make use of the exciting new world of the World Wide Web. The computer and communication technologies in general have changed things in the world of *work*, but we still struggle to find an important role for them in improving education.

Information technologies -- writing, the printing press, and onward... -- have brought a never-ending increase in the amount of information available to the general world population. And while this flow of information has proven to be useful in the workplace to those that have already gained the skills needed to filter through this infortmation, they have not, with the exception of writing, improved the overall level of education of the population. This is not to say that artifacts such as television and computers can't be useful as educational tools, it is just that currently, there negative effects far outweigh their positive effects [Mander 1991]. Also, many argue that the "medium is the message" [McLuhan 1964] and that television is doomed to have also have a net negative impact on society [Postman 1992]. However, with the web, the situation is more hopeful. The World Wide Web has increased the amount of information a person has easy access to, but it has done nothing to aid the individual in dealing with this information. In fact, like television, it often inflicts the individual with a feeling of passive submission. Informed, but inactive. This is evidenced by the small number of personal home pages and the even smaller number of those with any content other than links.

The web was originally designed by Tim Berners-Lee as a medium for active widespread publishing and collaboration between researchers, not as the one-to-many "tv-like" medium with the occasional list of a person's "favorite channels" that is most common today. [Berners-Lee, et al 1994] This situation probably developed for many reasons, including the difficulty of creating web pages directly using

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collaborative knowledge-construction that support both the individual and the group are needed. Nelson would be served just as well as a group of learners. And Nelson would be able to share his knowledge-space with others at will. While Berners-Lee was correct that the WWW has potential as a powerful tool for collaboration, there are at least two major stumbling blocks towards making this a wide-scale reality: 1) lack of group annotation capabilities, 2) reliance on screen or "media"-based authoring of hypertext content. Developing a system to overcome these hurdles is necessary to enable the elaborate and complex collaborative activities of group problem-solving on the WWW, whether the users are students in Jr High or physics researchers. [Annotations]

**Hurdles - Annotations**

The original design of the WWW included specifications for allowing both personal and workgroup annotations. Annotations in the WWW sense are simple comments attached to a document. Tney are visible to either just to the annotation author (personal) or to a defined set of people (workgroup). Personal annotations were implemented in early versions of the Mosaic WWW client software but workgroup annotations were not implemented likely because it was a substantial additional programming task and their were other tasks of higher priorities for the programmers of the WWW server software.

Lack of group annotations has meant that it is very difficult to make use of the web for substantial collaborative efforts. Single authors can make content available and create associative links to other already existing content, but collaborative creation and maintentence of content and links using the standard web interface and tools available is not really possible. From a technical implementation standpoint, there is one main issue that is not currently handled smoothly: link creation and maintainence. As mentioned above, creation of associative links from one's own content is currently possible. The essential problem is that creating links in *other's* content is not currently possible. This is the limitation of the WWW which group annotations were meant to deal with.

However, while the group annotation solution is relatively straightforward to implement, it is not a particularly attractive one because it is not flexible or general in the types of collaborative contributions or discussion it allows. The fundamental limitations of annotations are: "links" (not true links in the WWW sense) to annotations are attached to the bottom of the annotated page; annotations are not actual WWW documents. While it is theoretically possible for anntotations to contain HTML code and links to other WWW pages, the annotation is not a true WWW page and therefore cannot have additional annotations attached to *it*, and more limiting still, it cannot have associative links from a WWW page directly to it. [Annotations]

This is the level of tightly coupled functionality one would like to acheive with a distributed hypertext system meant for collaborative work. Right now, the WWW does not provide this sort of functionality in an automated fashion. Instead, to create a link from another person's page to one of your own pages, it means writing email to them personally and asking if they would "link you in". There are numerous systems that work on top of the WWW that attempt to improve on the limitations of the never-implemented Mosaic annotation concept. The best examples of fully automated systems include HyperNews [Hypernews] and the Threads program at the Hotwired web site [Threads]. The very best example of an online collaborative discussion with associative links between multiple viewpoints on a single issue (non-automated) is FEED Dialog [Feed]. We would like to be able to automate this level of functionality. Not to be forgotten in a discussion of related systems is Ted Nelson's still-a-pipe-dream Xanadu system [Xanadu] which would allow bidirectional links as well as automated notification of changes to marked pages using "sensors".

**Hurdles - Media-Based Authoring**

If one was to implement an automated method of annotating someone else's WWW pages by adding links to new WWW pages, one would have solved a large problem in preventing smooth automated facilitation of collaborative problem solving and discussions on the WWW. But another even more substantial issue would still be holding you back from making such a system assessible to those uninterested in the technical aspects of web publishing and HTML coding: the content and form of

HTML, and the fact that the server and client-side mechanisms for providing for at least some form of collaboration, group annotations, was only implemented in a limited form (personal and local-group annotiations, but not public annotations) by the NSCA Mosaic team at UIUC in 1993. [Annotations]

Instead of a new tool for providing interesting new ways for managing information and publishing on one's own, we are left with a tool that has been responsible for over-extending our abilities to make sense of the information available on the web. What we need today are tools to help us deal with this information and to help young people how to deal with this information on their own and most importantly, to focus and write down ideas of their own. This is not a skill which one comes by naturally -- one needs the assistance of people and tools to help provide structure, meaning and understanding to the flow of facts, theories, and ideas.

**Is Science to Blame?**

In some cases, the amount of information that we are faced with has increased simply because our understanding of the world on a scientific and social basis has become so intricate. In some areas of science, our understanding of the world has become so complex that it is increasingly difficult to relate the interelations and subtleties to a classroom of passive learners. Instead, it's necessary for the learners to take an active part in the learning process -- they need to actively construct understandings for themselves grounded in their everyday life and community. This is also very true for subjects like social studies, history, literature or any other topic that considers complex social, cultural or global issues. Being actively involved in the typical primary or secondary classroom can be difficult. 20 or 30 students is often too large a number of people to create an inclusive discussion where everyone is able to make their thoughts, ideas, and opinions heard. A computer tool can provide a medium where a person feels more able to at least initially have their voice heard. And people that feel they have a voice in an online discussion are likely to carry over their empowerment to their face-to-face interactions.

The MeTAL design is a system of WWW server- and a client-side additions that will create a useful collaborative learning tool in the classroom by adding functionality that automates the tasks that require the users to focus on the form of their WWW writings rather than their content. It also allows for adapting the viewing of this web of knowledge that individuals or groups have created according to the user's preferences. The primary focus of a young person's education should be on the thoughts and ideas of those in their place-based community. It has often been noted that students involved in distance learning projects with students or researchers in far-away places has not made them more intellectually curious or socially aware in their relations with students in their immediate environment. [Talbott 1994] Discussion and interaction with people they don't interact with on a daily basis are treated differently than those they have online with people that are "right-there". MeTAL's focus is on the "right-here" even when the topic is of global concern. See also [Global Lab].

**Hurdles Towards Reaching a Learning Web**

**Hurdles - Some Relevant Web and Hypertext Background**

In 1989, Tim Berners-Lee originally envisioned the WWW as a tool to be used by research scientists like himself in assisting in personal or group research projects. The WWW would be a powerful tool for collaboration, allowing one to easily organize and share one's research ideas and results with colleagues. As a cross-platform hypertext system, it would seamlessly integrate text and images, and allow one to easily create explicit logical links between implicitly interconnected material provided by multiple individuals. In contrast to this view of hypertext collaboration, Ted Nelson, the eclectic hypertext pioneer and visionary relates the following in comparing his and more traditional hypertext system designs, "...I just wanted to be left alone and given the equipment and basically to empower smart individuals and keep them from being dragged down by group stupidity. The amazing thing is that our designs have converged to some degree, showing, I think, the fundamental validity of this whole approach." [Nelson 1995]

This "group stupidity" that Nelson writes about I believe is due more to the current structure of educational environments, more than it is due to the human condition. Because of this, new forms of

WWW pages are intertwined. In other words, like virtually all computer-aided instuction systems of today, WWW pages are media-based, rather than knowledge-based [Murray & Woolf 1992]. What this means is that there is a severe limitation in the way that the pages are viewed by diverse users. Besides the ability of most WWW servers to easily let one set passwords on certain documents, and people having different settings for their WWW client software, the experience of all users will be essentially the same -- the presentation order of content and number and location of links remains unchanged. Group annotations would have solved this problem in a non-ideal way: users would see a different list of annotations at the bottom of documents according to the workgroup they are a part of. But a much more flexible solution can be envisioned.

**MeTAL: A Knowledge-Based Tool for Collaborative Knowledge Construction**

MeTAL (meta-tool for active learning) is a system designed to make students an active part of the learning process. Project-based learning environments (e.g. CoVis [Covis], LOGO [LEGO LOGO]) are a huge step in the right direction, but still leave out many students that don't feel they can make a personal contribution.

**Project Based Learning - Global Village or Globe of Villages**

"Being a socially competitive species, we naturally compare ourselves with people we see, which meant, in the ancestral environment, measuring ourselves against fellow villagers and usually finding at least one facet of life where we excel. But now we compare our lives with the fantasy lives we see on television... Our own wives and husbands, fathers and mothers, sons and daughters can seem profoundly inadequate by comparison. So we are dissatisfied with them and even more dissatisfied with ourselves." [Wright 1995]

Information continues to increase at a rapid pace, and with it, specialization in both work and play. It has become more and more difficult, as Robert Wright describes, to "find at least one facet of life where we excel." [Wright 1995] This is certainly true for students in our classrooms. It is hard to feel like you are an "expert" on a certain topic when you have direct access to Ph.Ds in the field at your fingertips. "Oh well. Why should I even lift a finger? The world is at my fingertips." What are the hidden messages of project- based learning projects that has communication with domain experts as a main tenet?

What happens when we let our students communicate at a young age with domain experts, or have them manipulate scientific data, collected in a far away place? Two things: The domain may be oversimplified and trivialized, and the students may be simply learning to be passive observers and manipulators of information rather than active participants in the learning process in their place-based community. Our classrooms need tools that bring students' minds back to their local community and back to the idea that THEIR ideas are ones that are worthy of respect. Students need to learn to trust themselves and not come to rely on the "big media" domain experts for the answers to their life and their community.

**The Form Versus Content Issue, Moderators, Voting, Verbal Skills and Democracy**

MeTAL takes the project-based approaches mentioned above one step further. Students' or groups' final work is not just presented, gathered up, and combined to produce a single class report that is never used or seen again. Students and teacher alike use the system in a collaborative effort and the system is designed to help students focus on their ideas and their writing, rather than on surface features like fonts and document formatting. The focus is on the process and not just the final product. Students are actively involved in the process of using MeTAL and students have an authentic reason to write -- to express their ideas.

In this sense, everyone that is using the system has the opportunity to contribute to the domain content of the system. However, some information (both content and viewpoints) will usually be somewhat fixed in the system as the use of MeTAL is typically moderated in the form of fixed, pre-existing links and nodes. Like a classroom discussion, the discussions that develop on MeTAL may be moderated by a teacher or student or they form around nodes created by a possible contributing domain expert. These node locations in the student's view of the group's information space need not be static. Because

document views are generated dynamically, the overall sturcture can change along with the content. See [Object Oriented Database - Queries, Dynamic Viewing] below. Some of additional features such as voting on nodes is possible as in the Idea Futures WWW system which is "... like a corn futures market, where one can bet on the future price of corn, here one bets on the future settlement of a present scientific controversy..." [Hanson 1990]

While developing good verbal skills is an important part of one's education, a classroom environment with 30 other students wanting to speak does not aid this development. In the end, the person doing most of the talking is the teacher. This is not the case with MeTAL. There is still the possibility that students get left out of the discussion on a certain day, but it won't be because they didn't get the chance to contribute. And for these students, much is gained by having the chance to traverse through MeTAL's nodes, following the direction of the person or people of their choice, thanks to the filtering capabilities of the system. The user can create, with the help of the system, their view of the topic, filtered both by difficulty of the node concepts and author.

Students play only a secondary role in the learning process in the typical primary and secondary school today. The teacher is doing most of the talking and it is clear that the classroom learning is in the hands of the teachers. MeTAL is a tool which can be used in a democratic, student-centered learning environment. Using MeTAL, students become active participants in the learning process. MeTAL breaks down the barrier between student and teachers and allows everyone's thoughts and ideas to be expressed. [Sudbury Valley School]

Hypertext is not inherently educational. [McKendree 1995] MeTAL is useful to students in secondary schooling that are at the point where they are able to engage in meaningful discussion of topics that goes beyond mere facts. Students benefit from MeTAL because they are able to experience different viewpoints on a given topic and take part in actively seeking out these different perspectives as well as generating ideas and opinions of their own. They are able to go further in the development of their ideas in a given domain because they are given a chance to work out their ideas in writing, as well as in person-to-person discussions facilitated by the ideas generated originally in MeTAL.

The World Wide Web is a flexible tool that can easily be used in a classroom as tool for helping students write. However, this flexibility comes in the form of lack of structure for the content. There is no control over what hypertext links a user creates on a given page or how these pages or links are formatted. Instead, like most tools for creating traditional ITSs today, it is focused entirely on the media, the text and the graphics and the HTML, rather than on the writing. Students and teachers alike are easily distracted by having to write and sort through HTML documents. Final projects of classes often look pretty, with fancy fonts and images downloaded from far away places, but the writing is not improved from the reports of past years. This is mainly due to the fact that it is too easy to get distracted by surface features (making use of the felxibility inherent in HTML) rather than focusing on their ideas and their writing. It's the problem of form vs. content. Like the EON ITS authoring tool [Eon] and other knowledge-based authoring tools, MeTAL helps the users focus on the content of the domain where student learning is happening, rather than on the details of how to display that information.

**MeTAL Hurdles - Computer Science Issues - Databases & Machine Learning**

At the heart of the MeTAL system is not simple text files with HTML, but rather a complex object-oriented database. Because of this, it is possible to do many complex things that are helpful in tutoring. One of these, is doing queries on the objects, rather than simple full text searches as at most web sites. Simple HTML attempts to provide structure to documents, but it is not enforced, seldom used, and more often abused to simply get the right look. In MeTAL, we can easily queries such as: "show me all comments made by me since last week" or "show me all refutation nodes made that are linked to nodes with 10 or more votes" See [Idea Futures]. The system generates documents dynamically from a database and users may restructure their views according to their own preferences. For instance, nodes that have had many hits or votes or annotations associated with them could gravitate to the "top" or the "center" of the knowledge space. We think of the collaborative knowledge space as a graph or a true "web" rather than a hierarchical tree as is the case with Hyper-G systems [Hyper-G].

Using machine learning techniques, MeTAL will be able to generate "leading questions" for given nodes. This will be an aid in prompting users to By making use of the top indexed words from the entire collection of documents (as collected from model authors, or from past, fully implemented instantiations of a domain of interest) we can prompt the user for more information. The top indexed words from the collection can be compared against the top indexed words of the given author's documents/nodes. Words that are not mentioned can be used in the "leading questions" mentioned above. "Do you have anything to write about (your) _____ ?"

**MeTAL Design Contributions**

MeTAL is important because it an attempt to make the benefits of hypertext available to students in secondary school. The WWW and WWW browsers are great resources but are too unstructured and focused on media aspects rather than on the content -- the students's ideas and writing. It is not a replacement for person-to-person discussions in the classroom but is meant as a facilitating tool towards improved dialogues, especially in the large, 30 student classrooms we often have today. Without a way to bridge the gap between verbal communication and the writing of all students, many voices don't get heard. MeTAL is a way to facilitate this sort of communication. The WWW, and the internet in general, is said to be a decentralizing force and one that flattens the playing field, giving the little companies and individuals more opportunity for growth and power and voice. While this is true in isolated instances, in general, the WWW most benefits large corporations and business, rather than education and individuals. MeTAL is a step in the right direction by making use of the WWW for authentic writing and communication by students in their place-based community or classroom.

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